



*Castilleja linariifolia*

# Castilleja

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## Pollination Primer

### 40 Years of Progress in Pollination Biology, and What it Means for Citizen Scientists<sup>1</sup>

By Nick Waser and Mary Price

Somewhat to our amazement, the past four decades, which roughly encompass our academic careers, have witnessed a substantial improvement in our scientific understanding of the pollination of flowers by animals. There is progress in science! Here we will sketch some of this progress, and explore what it implies for us as lovers of plants, citizen scientists, and citizen activists.

We begin with a quick review of pollination by animals. This is a ubiquitous ecological interaction in all terrestrial ecosystems. A pie diagram of the biodiversity of Earth represents some 1.5 million species that have been formally described by scientists (Figure 1). About one of every 6 is an angiosperm, or flowering plant—these are the dominant plants on Earth today, and have attained this status over the past 100 million years. By recent estimates, about 90% of these plant species rely on animals in whole or part to move their pollen around.

An amazing slice of the pie is insects, the dominant animals on Earth—over half of all described species. And most of the pollinators are drawn from this large pool of species, especially from the bees and wasps, the butterflies and moths, the flies, and the beetles—again about one in every 6 species. Add this up and about one third of all species are involved in the pollination interaction. Oh, and the vertebrates (a tiny slice of the

biodiversity pie) contribute some pollinators too—birds, bats, and others.

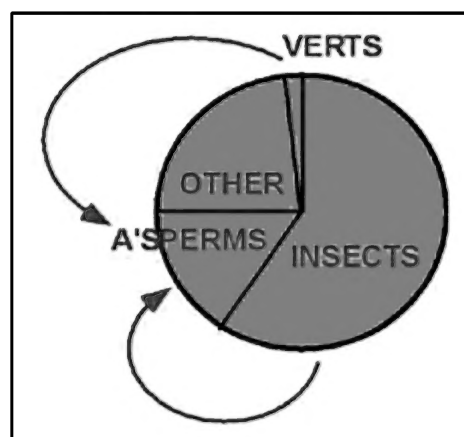


Figure 1: Biodiversity of Earth



Figure 2: Fruits of pollination (top photo) and fruits without pollinators (below). From Whole Foods.

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<sup>1</sup> Reprinted from: *Aquilegia* 41(1) – Winter 2017. 14-17 with permission of Nick Waser and Mary Price, Professors of Biology Emeritus, University of California Riverside, Adjunct Professors, School of Natural Resources and the Environment,

University of Arizona, and Principal Investigators, Rocky Mountain Biological Laboratory. All text and graphics © Waser & Price unless otherwise stated.

## WYNPS News

**2019 Annual Meeting:** Register *now* for 2019 annual meeting events, June 14-16. See the information and form in this issue for mail-in registration, or the WYNPS homepage for online registration.

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**New members:** Please welcome the following new members to WYNPS: Joyce Batson, Jackson; Jessica Brisbois, Cheyenne; Susan Drew, Wilson; Ami Erickson, Story; Gail Fustos, Pinedale; Katie Haynes, Laramie; Cheryl Mayer-Stisser, Custer, SD; Debra Patla, Moran; Rollin Sparrowe, Daniel; Dana Tully, Pinedale.

**Treasurer's Report:** Balance as of 27 Feb 2019: Scholarship = \$961; General = \$7,790.50; Total = \$8,751.50.

### **WYNPS Board – 2019**

President: Katy Duffy, Gardiner, MT  
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Vice-President: Lynn Stewart, Dubois  
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Board-at-large:  
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(2019-'20)  
Paige Wolken, Cheyenne ([paigewolken@yahoo.com](mailto:paigewolken@yahoo.com))  
(Completing the 2018-'19 term of Lynn Stewart)

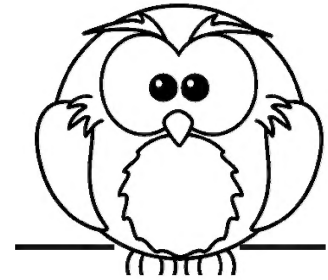
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Teton Plants: Amy Taylor, Treasurer;  
([tetonplants@gmail.com](mailto:tetonplants@gmail.com)). ...Check the chapter homepage (<https://tetonplants.org/>) for an exciting slate of talks, from September through May!

**Special Issue and New Newsletter Look:** Tributes to Ron Hartman, curator emeritus of Rocky Mountain Herbarium, are reprinted in this special issue of *Castilleja*. Accordingly, we are testing out a new approach at running longer issues with a lighter-weight paper so that we can still stay with the same mailing costs. If YOUR newsletter copy gets mangled in the mail, please send word. Comments and suggestions are always welcome!

## **Message from the President**



### ***Greetings!***

I am pleased and excited to be the new president of the Wyoming Native Plant Society! Why? Because I have loved wildflowers since early childhood when my grandmother introduced me to jack-in-the-pulpits and violets. When I moved to Wyoming in 1981, the first book I purchased was Craighead, Craighead and Davis's *Field Guide to Rocky Mountain Wildflowers*, followed quickly by Dick Shaw's *Plants of Yellowstone & Grand Teton National Parks*. I soon timed my hikes in the Greater Yellowstone Ecosystem to coincide with spectacular displays of my favorite wildflowers. While I coordinated the Teton Chapter from its inception in 1991 till I moved to Yellowstone NP in 1999, I had the good fortune to spend many hours in the field learning plants from superb botanists like Dick Shaw, Stuart Markow and Susan Marsh. During 16 years working for Yellowstone NP, I learned from (retired) park botanist Jen Whipple and current park botanist Heidi Anderson.

Now my time with renowned professional botanists and wildflower enthusiasts consists largely of annual meetings of WYNPS. At the 2016 meeting in Dubois, I was privileged to meet Ron Hartman who taught me about alpine wildflowers. Please see details on the 2019 annual meeting at South Pass in this newsletter so you can join this celebration of Wyoming's native plants—I look forward to seeing you there!

*Katy Duffy*

**Contributors to this Issue:** Robert Dorn, Katy Duffy, Emma Freeland, Bonnie Heidel, Lynn Stewart, Dorothy Tuthill.

**Next Issue:** Please send articles, ideas and announcements for the next issue by 15 April.

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Wyoming Native Plant Society  
P.O. Box 2449  
Laramie, WY 82073

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## 2019 Wyoming Native Plant Society Annual Meeting, June 14 -16 in the Atlantic City Area

**Camping** – Big Atlantic Gulch BLM campground, \$6/night/site.

**Lodging** – Miners Delight Inn 290 S. Pass Rd, Atlantic City – S end of town. Inn will be open just for the meeting. Price list for rooms in the Inn & cabins is at the end of the agenda. Call 307-714-0100 for reservations. minersdelightinn.com Kitchen available for guest use.

### Friday, June 14

**Check-in 2 – 6 p.m.** Miners Delight Inn, 290 S. Pass Road, Atlantic City. Meeting registration \$10/person requested.

### Evening Stroll

Meeting Location: Miners Delight Inn

Meeting Time: 6:30 p.m.

Leaders: Emma Freeland & John Mionczynski

Description: An evening stroll through the sagebrush, aspen, and pine stands to see wildflowers of Atlantic City.

### Saturday, June 15

**Hikes** For all hikes: bring water, snacks, sunscreen and rain gear. For all-day hikes: also bring lunch.

#### 1. Oregon Buttes – all-day hike

Meeting Location: Miners Delight Inn

Meeting Time: 8:00 a.m. (high clearance vehicles and carpooling are encouraged) Leader: Bonnie Heidel

Description: A strenuous hike to the top of Oregon Buttes, a landmark of the Oregon Trail, to view summit panoramas, 1849 journal recount of the same hike, and floristic meeting grounds (weather-permitting).

#### 2. Desert Yellowhead and Other Rarities – all-day hike

Meeting Location: Miners Delight Inn

Meeting Time: 8:00 a.m. Leader: Emma Freeland

Description: A moderate hike of about 3 miles through sagebrush to see desert yellowhead (*Yermo xanthocephalus*), a threatened species endemic to the Beaver Rim area. On the hike we will also see a handful of other regional endemic plants, including Beaver Rim Phlox and Cedar Rim thistle.

#### 3. Shoshone NF – Limestone Lovers – morning hike

Meeting Location: Miners Delight Inn

Meeting Time: 8:00 a.m. Leader: Kassy Skeen

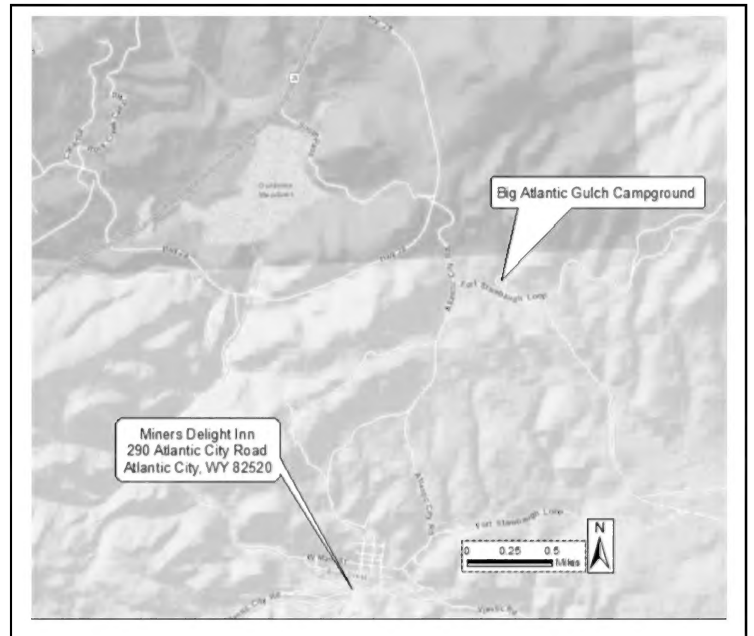
Description: An easy to moderate plant walk of a few miles to see sensitive endemics in limestone layers of this region.

#### 4. South Pass City area – afternoon hike, \$3/person for entrance to historic site

Meeting Location: Miners Delight Inn

Meeting Time: 1 p.m. Leaders: Jack and Diantha States

Description: An easy hike on a 2-mile section of the Continental Divide National Scenic Trail at the South Pass City Historic Site.



**Note:** Nearest gas is in Lander - 30 miles north, and Farson – 48 miles south.



Left: Atlantic City; and Miners Delight Inn

**Saturday Evening Potluck Dinner, 6 p.m. – Miners Delight Inn**

Bar will be open for beer, some mixed drinks, single malt scotch

**Saturday Evening Presentation, 7:30 p.m. - John Mionczynski: The Ancient People of South Pass, and Their Plants**

**Sunday, June 16**

**Business meeting, 8 a.m.** Miners Delight Inn. Everyone is welcome! (Breakfast provided – bring your coffeecup)

**Hikes** For all hikes: bring water, snacks, sunscreen and rain gear. For all-day hikes: also bring lunch.

**1. Clovers of the Canyon** – morning-early afternoon hike, bring a lunch

Meeting Location: Miners Delight Inn

Meeting Time: After the business meeting

Leader: Maggie Eshleman

Description: A moderate, ~3 mile round-trip hike through scenic Red Canyon to see Barneby's clover, a species endemic to the area. This hike will include some light rock scrambling.

**2. South Pass City area** – morning hike, \$3/person for entrance to historic site

Meeting Location: Miners Delight Inn

Meeting Time: After the business meeting

Leaders: Jack and Diantha States

Description: An easy hike on a 2-mile section of the Continental Divide National Scenic Trail at the South Pass City Historic Site.

**3. Sinks Canyon** – all-day hike

Meeting Location: Bruce's Bridge Trailhead Parking Lot in Sinks Canyon

Meeting Time: 10:00 a.m.

Leaders: John Mionczynski

Description: An easy walk through the diverse habitats of Sinks Canyon, with a focus on ethnobotany.

**REGISTRATION**

This event is open to the public; membership in the Society is not required. However, registration is required. Please register by May 31, 2019. No dogs, please, on any of the hikes.

Name(s) \_\_\_\_\_

Address \_\_\_\_\_

\_\_\_\_\_

How many people are you registering for? \_\_\_\_\_

Registration fee is \$10/person. Payment enclosed: \_\_\_\_\_

Which days do you plan to attend? Please circle.

Friday      Saturday      Sunday

Please return this by mail to WYNPS for receipt by 31 May, or register online at [www.wynps.org](http://www.wynps.org)

**Hike registration**

Saturday

\_\_\_\_\_ Oregon Buttes

\_\_\_\_\_ Desert yellowhead

\_\_\_\_\_ Shoshone NF (am)

\_\_\_\_\_ South Pass (pm)

Sunday

\_\_\_\_\_ Clovers of the Canyon (am)

\_\_\_\_\_ South Pass (am)

\_\_\_\_\_ Sinks Canyon (all day)

Reservations at Miners Delight Inn must be made in advance. The cabins range from \$120-140/night, rooms at the inn range from \$140-\$160/night.

\_\_\_\_\_ Do you plan to camp at the Big Atlantic Gulch Campground? Which nights? Friday      Saturday      Sunday

### Ron Hartman: Early Years

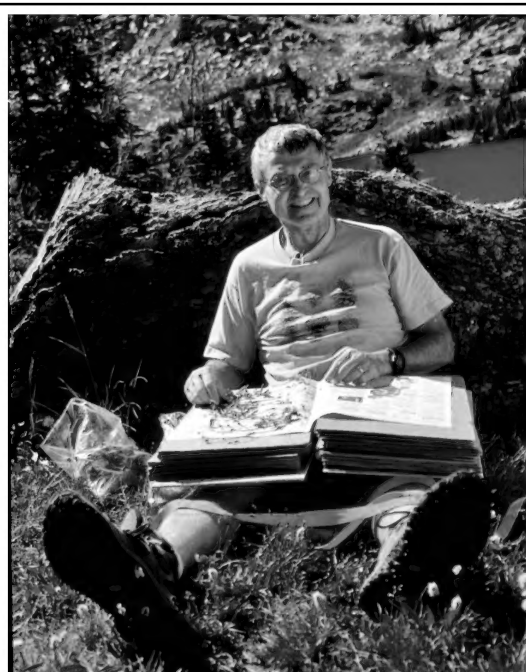
Dan Crawford  
University of Kansas,  
Lawrence, KS

Ron was totally immersed in his MS work on Caryophyllaceae in 1969, but, not surprisingly in retrospect, showed considerable interest in umbels. The family was also the subject of my MS thesis, so we decided to do a survey of chromosome numbers for Rocky Mountain umbels as a “side” project. We went on several field trips in the Rockies during the summer of 1970. Ron was in charge of getting together locality data, for identifying the species in the field, and for making critical taxonomic observations on some very difficult groups. I counted the chromosomes. The results were published in *American Journal of Botany*. It was clear that Ron had an amazing eye for plants and that he dearly loved being in the field. When he was leaving for Austin to pursue doctoral work, he commented that being Curator of RM would be his dream job. It is rare when one can obtain his/her most coveted position and spend a lifetime doing what one loves. Charlotte Reeder commented in 1971 that “Ronito” would love to go on a field trip for the rest of his life; that is exactly what he did, and in the process he built one of the most important collections of plants in the world.

### Ron Hartman: FNA Colleague

Luc Brouillet  
Université de Montréal, Montreal, Quebec

I would like to express to all who have known him [Ron Hartman] my appreciation for a great colleague, with whom I worked more than 30 years on the Flora of North America Project (FNA). His impact and dedication were acknowledged by all. I was also impressed by his incredible dedication to floristic work in the field in the Rockies. The North American botanical community owes much to his efforts.



Above: Ron Hartman.  
This issue of *Castilleja* is dedicated to Ronald L. Hartman, Curator Emeritus of Rocky Mountain Herbarium. We reprint tributes and testimonials from a celebration of his life on Feb 8, 2019 at the University of Wyoming.

### Ron Hartman: Botanist Extraordinaire

Tim Lowrey  
University of New Mexico,  
Albuquerque, NM

Ron Hartman's botanical contributions include building the Rocky Mountain Herbarium into a national and international resource, being one of the most prolific modern botanical collectors, training a generation of botanists (who are employed throughout the country), becoming an acknowledged expert on the large and important plant families of the Asteraceae, Caryophyllaceae and Apiaceae, editor, author of numerous botanical publications including species new to science, teacher, and colleague to botanists across the country. Ron is unmatched, in my opinion, among his contemporaries in amassing these achievements.

Being in the field with Ron Hartman is a wondrous botanical experience.

He is compelled to make as complete a collection of an area as is humanly possible. Collecting with Ron was like conducting a successful military campaign: intense, organized, thrilling, sometimes dangerous, and thoroughly exhausting. One of my colleagues once wrote to me, “His passion for plants, his love of the outdoors, and his ideal base of operation in Laramie have been essential ingredients in the creation of one of the most ambitious, broad, and intensive floristic projects ever undertaken in any part of North America.” He is a “force of nature” in floristic botany, which, despite its increasing importance to humankind, is in general decline throughout the world. The inventories he completed or supervised and the specimens collected by him and his students will be studied by future generations of scientists. Most of these scientists will be unaware of the monumental effort that went into obtaining these collections yet their research will be dependent upon them in some significant measure. The state of Wyoming, for example, has a documented inventory of its vascular plants that is probably unparalleled in the U.S. in its scope and thoroughness.

Ron has also been a leader among herbarium curators in herbarium databasing and making the data available electronically. While the collections themselves are of fundamental importance it is also

just as important to make the collection data available to researchers. It would be like having a library of books that few could read. Through his efforts researchers around the world are now able to access the vast collection data via the internet.

Ron has also made major contributions to our knowledge of botanical diversity through his publications, particularly in his contributions to completion of the Flora of North America as editor and author. This ambitious effort to provide a floristic treatment for all plants in North America north of Mexico has greatly benefited from the floristic treatments completed by Ron and his botanical colleagues. I am proud to have been his colleague and friend over these many years.

Ron Hartman: Consummate Collaborator

Rich Rabeler

University of Michigan, Ann Arbor, MI

I first met Ron in December of 1985 when he was on sabbatical at the University of California herbarium working on the Caryophyllaceae treatment for the Jepson Manual project. I was visiting Berkeley to work with Tom Duncan on a statistical analysis for my dissertation at Michigan State University. Little did I know that this chance meeting was the beginning of a l-o-n-g (33 year) and fruitful collaboration.

Our collaboration got quite serious when it was time to complete the Caryophyllaceae treatment for the Flora North America project. Ron had gotten both myself and Craig Freeman seriously involved in FNA, getting both of us involved in the Board of Directors and laying the groundwork for a long editorial collaboration between Craig and myself. In the mid-1990s, Ron introduced me to using spreadsheets for making parallel descriptions – a very useful concept that I’ve used many times since. Ron and I agreed to edit the Caryophyllaceae for FNA. After getting most of the collaborators to complete treatments, there was one significant “hole” left before the volume could go to press in 2005. Completing those three genera brought me to Laramie on 3 occasions in 2004 for extended work with Ron. Between his experience in the West and mine in the East, we had a reasonable handle on many of the species; in 2004, we figured out that we had 64 years of experience in the family between us. I remember these sessions well, working with Ron at the RM gave me an appreciation of how much he had invested in the RM - how excited he was about it, his

students, and the floristics of the Rockies program that he had built.

Our collaboration after the FNA treatment was completed continued with a revision of his Jepson treatment of California Caryophyllaceae and then on to similar treatments for the Flora of Oregon and we were working on the Flora of New Mexico until about two months before his passing.

Two other things come to mind that I’d like to share. In the 1990s Ron and I both independently became aware of an undescribed species of what we thought was a *Pseudostellaria* in the Feather River Canyon area of California. We described it in 2002 and later he rediscovered an extant population of a closely related, but very rarely collected, species in Idaho. A molecular study by a team of Chinese botanists revealed that these two species represented a new genus. When that team asked for assistance with a name, I thought for a while – how about naming it after Ron? After all, he helped discover the California endemic, it also grew in the northern Rockies, an area where he had a long-standing floristic interest, and it was a fitting honor for someone who had studied the family for many years. *Hartmaniella* was published in July of 2017.

Although some of what we planned did not go as we hoped, I feel very blessed to have known and worked with Ron for so many years – and to think of the things that I would not have experienced/ accomplished if our paths had not crossed. Many of us who knew Ron can likely relate to this – we miss Ron, but we most certainly benefitted from knowing him.

Ron Hartman: Mentor and Friend

Hollis Marriott

Consultant, Laramie, WY

I’ve known Ron since 1978, when I contacted him about a milkweed not previously reported for Wyoming. I became his grad student in 1982 and then a colleague, but the most important thing to me during all those years was our friendship. I’m pretty sure that when I think about Ron in the future, what will come to mind won’t be the running, rock climbing and crazy parties of our youth, or even botany, but rather his extraordinary determination in the face of Parkinson’s, manifested in exercise and herbarium projects. What a great role model!



### Ron Hartman: Field Legend

Craig Freeman

University of Kansas, Lawrence, KS

Ron was a consummate field botanist with few equals. His passion for plants, his love of the outdoors, and his ideal base of operation in Laramie were essential ingredients in the creation of one of the most ambitious, broad, and intensive floristic projects ever undertaken in any part of North America. Spanning almost 40 years and including nearly 60 individual, multi-year inventories in a dozen states, the hundreds of thousands of specimens gathered by Ron and the staff and students of the Rocky Mountain Herbarium provide an unparalleled view of the floristic diversity and patterns of the Rocky Mountains. While floristic research in the U.S. has been in general decline, Ron somehow bucked the trend, garnered support for his enterprise, and got the work done. Decades will be needed to analyze the data and synthesize the results of this extraordinary endeavor.

Ron's intensity, energy, focus, and drive in the field were legendary to those who ever participated in any of his "forced marches". I joined him and his students several times when they were conducting surveys in the Sangre de Cristo Mountains in south-central Colorado. Cognizant of the harrowing accounts of uninitiated colleagues who accompanied Ron on forays into the back country, I always put in extra training time in advance of my trips with Ron. I was ecstatic that I usually managed to keep him in sight—if just barely—as he strode purposefully along forest trails or lithely bushwhacked his way toward a distant summit, stopping intermittently to identify and collect. A collecting trip with Ron was a workout for both body and mind.

During one particularly memorable trip, Ron and I decided to spend an afternoon collecting in the vicinity of the town of Cuchara in south-central Colorado. A brisk four-mile hike got us quickly to our target summit. After exploring and collecting, we decided to head back to Ron's truck. It was getting late and threatening rain. During the descent, our individual interests separated us; Ron ended up on the trail at the base of the mountain, but I was far from it. It was nearly dark by the time I realized my predicament. I could hike back to the top of the mountain to get my bearings or follow a stream that I knew would lead to a highway, albeit ten road miles from our starting point. I opted for the highway, arriving at the porch of an unoccupied cabin in the dark at the onset of a downpour. When the rain

yielded, I hiked to Cuchara. It was midnight, so I stopped to rest on the porch of a shop until I could thumb a ride with a passing motorist. Soon after arriving, a troop of marauding black bears at a nearby dumpster convinced me and my granola bars to shelter in a phone booth, where I stayed for four hours until I flagged down a passing taxi. In exchange for a ride to Cucharas Pass, I agreed to help the driver deliver a set of golf clubs. After searching unsuccessfully for an hour to find the address, the driver delivered me to the pass. I hoofed the last five miles to where the journey began the day before. Rounding the last road bend at sunrise, I caught sight of Ron's truck. Relief washed over me when I found him sleeping on the front seat. Ron awoke, wryly observed that I had not succumbed to the elements, and we proceeded to the next collecting site. I was thankful Ron stayed calm and stayed put; this clearly was not his first rodeo. He, I think, was relieved he didn't have to call search and rescue to help find his stupid flatlander friend, and maybe just bit envious of my adventure once apprised of the details.

### Ron Hartman: Runner

Melanie Arnett

WY Natural Diversity Database, Laramie, WY

One of the best ways I can think of to honor Ron's memory is to donate to the Pilot Hill Project in his honor. Ron was a runner, and he loved the Pilot Hill Classic race, Wyoming's oldest footrace. I know from personal conversations that the Pilot Hill Project was very meaningful to Ron. Just last summer Ron and I managed to get out and work on a botanical checklist of "The Schoolyard", a state section of land that connects Laramie to the Pilot Hill Project property. Our efforts were in anticipation of the Pilot Hill property becoming accessible to the public once again. We were both so excited.

On the night that Ron announced on FB that he was "on his way out", I was lucky enough to be able to make a midnight run to Loveland and visit with him at the Medical Center of the Rockies. He was in good spirits and made me laugh as he recalled minute details of my first season of field work in the Southern Gunnison Basin. He asked how the Pilot Hill Project was going. When I told him we just had confirmation that a land swap had been initiated and would very likely succeed, his face contorted with emotion. He asked for details and was overjoyed to hear about this new potential avenue for success of the project.

### Ron Hartman: Laying Foundation for Floras

Noel and Pat Holmgren  
New York Botanical Garden, New York, NY

We remember Ron Hartman as a consummate, dedicated, legendary plant collector. His collection numbers reached 93,000+, an achievement reached by very few. Ron identified areas in the Mountain West most in need of botanical collections and followed through in securing funds to support fieldwork for him, his colleagues, and his students in those areas. His enthusiasm for fieldwork was transferred to the next generation, a major accomplishment lacking today at many universities. His disciplined approach to fieldwork resulted in major collections that forever document what grew where and when it grew there.

He and his colleagues and students selflessly prepared duplicates of their collections and generously shared them with herbaria throughout the U.S. and elsewhere. In return, these exchange duplicates brought back specimens from elsewhere, helping the Rocky Mountain Herbarium to grow exponentially during Ron's tenure as Director. Collections made by Ron and his colleagues were enormously useful to the authors of Intermountain Flora (Arthur Cronquist, Arthur Holmgren, Rupert Barneby, James Reveal, and Holmgrens) as they prepared species descriptions and distributions.

Ron came to New York to run in the New York City Marathon long ago (maybe 1979 or 1981). The Marathon takes place on Sundays. Ron wrote to us ahead of his trip, requesting permission to work in the New York Botanical Garden Herbarium on Saturday, the day before the Marathon. Ron's dedication to botany led him to spend the day working in the Herbarium rather than enjoying the sights of New York City. We note, however, that he made no plant collections on the day of the Marathon. Rest in peace, Ron.

### Ron Hartman: Dedication in Action

William Reiners  
University of Wyoming, Laramie, WY

We all know of Ron's ardent pursuit of systematic questions and of management of our herbarium. To say "ardent" is an understatement. Ron's commitment to expanding the Rocky Mountain Herbarium (RMH), and thus our knowledge of the Wyoming and Rocky Mountain region flora, may better be described as full-bore, whole-being, single-minded, devotion. I question whether any other of

his colleagues (including me) were as completely committed to their careers as was Ron.

Furthermore, Ron's dedication led to tangible results—perhaps more tangible than the publications most of us have to show for our careers. Others can better describe Ron's expansion of the plant collection, his training of scores of field botanists, his leadership in the Flora of North America program, his peer-reviewed publications, and his pioneering adoption of a digital online program. As a result of Ron's devotion, UW has one of the largest herbaria in North America and by far, the best regional collection stretching from Montana to Arizona. The specimens acquired and recorded are not only invaluable as data for traditional floristic and phylogenetic purposes, but as distribution data in the face of ongoing climate change, and as materials for DNA, chemical and isotopic analyses.

We can note that Ron's work was carried on before "biodiversity" became a topic of biological interest and environmental action. His efforts have given us the largest and most detailed biodiversity information of any Wyoming biological group in our environment. When the history of UW Botany is written, Ron's work will be viewed as the most significant legacy of our time not just from a botanical viewpoint, but also in terms of the incredible foundation he created for knowing about the diversity of our environment. We should all strive to make that point as the topic of "biodiversity" is carelessly discussed in the current environment.

Farewell Ron. I wish you could know how much we respected you as dedicated scientist whose works really mattered, and how we remember you as a good man.

### Ron Hartman and his RM Legacy

Dennis Knight  
University of Wyoming, Laramie, WY

I've known Ron since 1969, the year he arrived in Laramie to begin work on his M.S. degree—50 years ago. Like many of us, I suspect he was attracted to Wyoming by the mountains, grasslands, and deserts, and by the fact that the land, as far as you could see in nearly every direction, was still dominated by native plants. Ron grew up in Illinois, surrounded by cornfields. As we all know, Ron liked adventure. Wyoming must have seemed like a wild place to study and live.

In more ways than one, Ron was like Wyoming's first botanist—Aven Nelson. True, Wyoming was a much wilder place when the 26-year-old Nelson



arrived in Laramie, in 1887—82 years before Ron. In fact, Wyoming would not become a state until two years later. Aven Nelson was the first faculty member to arrive on campus. He was actually hired to be an English Teacher, but, by mistake, two English teachers had been hired and no biology teachers. Fortunately, our department's founder had taken a course in biology. That qualified him to become UW's first biologist. He must have had a latent love for plants, as the Rocky Mountain Herbarium (RM) was established only 12 years later, in 1899—120 years ago.

During Aven Nelson's first years at the university, he taught botany, zoology, human physiology, mathematics, and calisthenics. He also was the librarian, state horticulturist, and eventually he became the university's president (1917-22). No wonder Roger Williams was motivated to write Nelson's biography. It's a great overview of how plant systematics developed as a profession and about the history of this place where many of us have chosen to study and work.

To be sure, Ron's accomplishments were much different than Nelson's, but as you will hear from others, his list is long as well. Ron, too, was a pioneer, a pioneer in his approach to doing floristic studies, his application of modern tools for the systematic treatments of difficult genera, becoming a founding collaborator for the Flora of North America project, and the way he led the way in using digital technology and the internet to enable so many of us to reap the benefits of the Rocky Mountain Herbarium from afar. More than any other curator, including Aven Nelson, Ron elevated the RM's stature to what it is today. Aven Nelson would be astounded.

Like Aven Nelson, Ron was an adventurer. Growing up on the shores of the Mississippi River, he and his brother David constructed rafts and floated downstream. During the summer while in college, he guided wilderness trips in the mountains of northern New Mexico. In the tropics, he explored Darien, a vast wilderness in Panama. After one trip, Ron told me with a laugh that, to facilitate his work, he was having a house built in a riverside village on the edge of Darien. As I recall, it was either a palm-thatched hut with no walls, or maybe it had bamboo siding and a tin roof. Ron didn't need much to be comfortable as long as he could pursue his research. Aven Nelson roughed it on his own expeditions, the best known of which was to Yellowstone National Park—a major undertaking in those days. Both were equally excited about the potential of finding plants unknown to

science, extending distribution ranges, and documenting that some plants thought to be rare are in fact common.

When Ron arrived for graduate school, John Reeder had become the curator of the RM and would become Ron's thesis advisor. Other mentors were Professor Cedric "Ted" Porter and Assistant Professor Dan Crawford. Ron's interest in Wyoming might have been kindled by a plant taxonomy course at Western Illinois University, where the instructor very likely used Ted Porter's popular textbook. Ted was Aven Nelson's successor as curator. When Ted retired, John Reeder was hired to be department head and herbarium curator. Fortunately for Ron, John stayed at Wyoming for only seven years—just enough time for Ron to finish his M.S. degree at Wyoming, earn his Ph.D. from Texas, and gain post-doctoral experience at Ohio State. Ron's qualifications and passion for the job made our decision to hire him an easy one. Indeed, considering all that he accomplished, curating the RM was a labor of love from the beginning.

Systematically, Ron and his students, and soon, Ernie Nelson, worked their way up and down the Rocky Mountain region, meeting the needs of conservationists, ecologists, managers with the various agencies, and those studying the biogeography and evolution of one plant group or another—all the while building the RM into the collection that it is today. With the passage of the Endangered Species Act, federal and state land managers sought Ron out because they were convinced his program was the best one for this kind of work. That was important because, without accurate data on threatened and endangered species, the agencies could end up in court. The stakes were high.

Overall, Ron Hartman has done more to provide a basis for the study and conservation of plant diversity in the Rocky Mountain Region than anyone else, living or dead. In closing, I would like to read a sentence that Roger Williams found in the writings of Aven Nelson. Aven Nelson wrote, "The road that seems to lead into unexplored fields is singularly attractive, especially so if hazards seem to bar the way." Aven Nelson, the father of our department, would be amazed with the results of Ron Hartman's botanical research and with what he accomplished as curator of the Rocky Mountain Herbarium.

## Ron Hartman: Educational Brand of Excellence

Walter Fertig

Washington Natural Heritage Program, Olympia, WA

When people learn that I studied botany at the Rocky Mountain Herbarium, they often ask if I worked with Ron Hartman. When I reply that I did, they usually follow up by asking if all the stories they have heard are true. To this, I always respond: yes - the stories are all true. As well as the stories they have not heard!

The thing is, Ron Hartman and his antics are legendary in the small world of western botany. For openers, few people (outside of Laramie) can fathom how a single person could collect 93,393 vascular plant specimens in one lifetime. That was Hartman's output from approximately 1967 to 2014, when health issues caused him to put the plant press away - an average of 1,987 specimens a year! There are few taxonomists who end their careers with 1,987 specimens total! This is one record that might never be broken (except perhaps by Ernie Nelson- Ron's partner in managing the RM for over 40 years). For some perspective, my friends consider me a hay-baler with over 30,000 collections, but at my historic rate of activity I will need 57 years to meet Ron's total. When I am 112 years old.

When Ron arrived as curator of the RM in 1977 (after an earlier stint as a Masters student), the herbarium was already quite sizeable for a public university, with nearly 300,000 collections. Over the next 40 years Ron, Ernie, and their army of masters students and undergraduates added 640,000 specimens from across Wyoming and the Rocky Mountains from eastern Washington to Montana and south to Arizona and New Mexico. As a result, the RM is now THE premier herbarium in the entire Rocky Mountain west. More importantly, the composition of the flora across this entire region is among the best documented in the United States - rivaling much more densely populated (and densely botanized) portions of California and the northeast or midwest. One could argue that Wyoming has one of the best-documented floras in the world! This is a remarkable accomplishment for the University of Wyoming. How many other programs on campus can be called one of the best in the whole world?

More than 20 years ago Ron Hartman recognized the value of having the RM label data captured in digital format and available in a geo-referenced online database. This is a common practice today, but was in its infancy in the 1990s. As a result of decades of data entry (now augmented with

specimen images), there are over 853,000 locations records on the RM database and hosted on SEINet, one of four main regional data portals. Only the New York Botanical Garden, the largest herbarium in the US, has more digital specimen data than RM on-line.

So why is all of this collecting and databasing valuable? Initially, Ron's intention was to have better coverage of the flora across the Rockies so that a team of taxonomic experts might write a multi-volume, illustrated regional flora, like that of the Intermountain Region or Pacific Northwest. Unfortunately, this never came to fruition in Ron's lifetime, though the data are there, waiting for the right team of people to seize the opportunity. The data have been extremely useful in fleshing out the distribution of western species, in developing species checklists of national parks and other protected areas, in assessing the rarity and distribution of special status plants, in discovering dozens of new species for science, and providing raw material for research on biosystematics. More and more, I believe the real value of these collections will be as a gene bank for future research, especially since deriving usable DNA from dried specimens has moved from theoretical to practical. Repositories like RM will be invaluable for the raw material needed for this line of cutting-edge research - so long as we keep them around!

Ron Hartman left a real legacy behind. He published a lot - nearly 100 papers on taxonomy and floristics and many more unpublished reports on rare species and local floras for land management agencies. He oversaw nearly 50 masters projects over 40 years and many of his students have gone on to become professors with their own students, or botanists for the Forest Service, Park Service, or BLM, or herbarium managers, or state heritage botanists. He even played match-maker for a few sets of his students (including my wife Laura - RM class of 1997 and me - RM class of 1992!).

What impresses me about Ron Hartman is his final act - once he became diagnosed with Parkinson's disease and ultimately cancer. Ron vanished for a time, actually getting treatment and correcting his medications, but leaving many of his colleagues clueless about his condition and whereabouts. It was during this period when Ron's peers began to formally recognize him with several awards and honors celebrating his lifetime of accomplishments. These included the Distinguished Service Award from the American Society of Plant Taxonomists, the "Ron Hartman Excellence in Wyoming Botany" award from

the Wyoming Native Plant Society, and the Wyoming Biodiversity Science Award from the University of Wyoming's Biodiversity Institute. Ron even got a second plant genus named after him: *Hartmaniella* (a segregate of *Pseudostellaria*) to go with an earlier name *Elaphanadra* (*Elaphus* -a genus of deer, or "hart" and andrus, "man") for a tropical sunflower. Fortunately, Ron survived his first brush with serious illness, and got to see how his colleagues felt about him and his work. I think it had a big impact on him. He certainly seemed like a new man in his post-retirement life. He was slowed a little by Parkinson's, and was shakier, and spoke more softly. But he also had an impish glow and seemed to be basking in well-deserved praise and acceptance. He finally really seemed at peace.

### Ron Hartman: Vision, Persistence...and Shorts

Emma Freeland

Bureau of Land Management, Lander, WY

I first met Ron in the fall of 2010. I set up a meeting with Ron to learn more about the floristics program. Our meeting was more him showing me the herbarium and asking about my experience in the backcountry than it was hashing out mundane details like coursework and GRE scores, and I was totally sold. I knew immediately I wanted to apply. I dropped my other grad school applications, and decided to commit to the floristics program 100%. I saw Ron a lot that winter when I was working in the RM, I was honestly a little intimidated by him. I couldn't figure out who this guy was who came in wearing shorts, even in the coldest Laramie mornings. He'd generally come in, announce, maybe to Ernie or maybe to everyone else, the distance and speed of his walk that morning, and get to work behind the microscope. We didn't talk too much, and he was a bit of a mystery to me.

That spring, I was admitted to the floristics program, but with the caveat that there wasn't a project ready for the coming summer, so I'd have to wait until the following summer to start my field work for my own project. In the meantime, he convinced me to join him on a collecting billed as a trip for me to get to know the program a little more, ...but I also think he wanted to see what I was made of, see if I was tough enough for a floristics project. He even told me he wanted to make sure I would "make it up into the alpine often enough" on my own project.

If I was intimidated by Ron in the herbarium, I found him highly approachable and fun in the field.

Our first stop on the trip we got hotdogs and Doritos at the Flying J outside of Rawlins at about 9 in the morning. I found Ron to be highly motivated but also surprisingly laid back in the field. I also saw that physical activity was Ron's sanctuary: on plant pressing days, while Jessica and I took a break for lunch and relaxed a little bit, he would slip out the back door for a five mile power hike. Hard work and giving it all you had was paramount to Ron: I found myself running uphill in hiking boots just to try to keep up with him, which is an experience I'm sure many of his students remember as well.

Over the next year, he relentlessly pursued funding from various Forest Service and BLM offices for my project, in a climate where funding of this type was drying up. He used a term I appreciate even more now that I'm a federal agency employee myself, he called his meetings with federal employees "education." He felt that if they just understood the importance of this type of work, they'd come around and fund these floristics projects in full. And he was right. I was eventually funded to do floristic work on the Beaverhead-Deerlodge National Forest in Montana, a project that was a once in a lifetime experience that helped instill in me a love of botany and the mountains that I still carry today.

Ron's legacy touches my life through the amazing resource that is the Rocky Mountain Herbarium and online database. It is no exaggeration to say I open up the online RM database every week in the winter, and pretty much every day in the summer. I am intimately familiar with the collections of his students Laura Welp who botanized the Great Divide Basin, Rob Massatti who botanized the east slope of the Wind River Range, and Rachel Newton who botanized the wetlands of the Sweetwater Plateau. I am also the current sponsor for the most recent floristics project: A Floristic Inventory of the BLM Lander Field Office, one of the last that Ron set up in his life. That work is being done by Caitlin DeCastro, under the mentorship of Ernie and Greg. The project was set up before I started working there, so I can't take credit for making it happen, but I always joked with Ron that I was "one bureaucrat he didn't have to educate." Which is ironic, since I was his student. Anyhow, I feel so grateful to work in this state with such an abundant herbarium resource, and I have Ron's persistence and vision to thank for that.

Ron Hartman: Pacesetter

Neil Snow

Pittsburg State University, Pittsburg, KS

Earning a MS degree at the Rocky Mountain Herbarium was one of the highlights of my life. I began as Ron's student in Spring semester of 1987. I'd started grad school at University of Texas-Austin in 1985, where Ron had done his doctorate and was still well known, but decided to do a floristics survey instead. My thesis covered the southwestern Absarokas, which seemed logical given that Rob Kirkpatrick had finished the southeastern Absarokas shortly before I arrived.

Our first collecting trip was in northern New Mexico in May of 1987, organized by USFS botanist Reggie Fletcher. A sizeable group (15 perhaps?) did general surveying on the Jicarilla District of the Carson National Forest in Rio Arriba County for about 3 days. It was a great trip. It was then that I learned Ron's collection approaches. The trip was particularly memorable for me because my father tagged along (he who had taken plant taxonomy with C. Leo Hitchcock at the University of Washington in 1963 on a school-teachers' sabbatical), and because my undergraduate advisor, Dieter Wilken (now retired from Santa Barbara Botanic Gardens) was on the trip as well. Fun times... and the thrill of learning those new genera never ceased.

Ron and I hit it off well overall. We both had achieved Eagle Scout. We also were runners, although his achievements far surpassed mine. He ran some marathons, but not I. However, we walked the equivalent of a marathon one summer day in June of 1987. We parked a truck at one trail head and drove to another, somewhere near Togwotee Pass. We started walking sometime between 1 and 2 PM. I knew of his reputation for a blistering trail pace (he who had 40 or 50 miles one day perhaps 5 years earlier). As such, I expected that we'd raise a hefty plume of trail dust and cover some territory.

And man, did we ever. I'm a tall guy with a long stride. He and I easily were walking 4 miles an hour at times. Of course, we stopped periodically and bailed hay. But he kept going in the "wrong" direction (to my mind) up a drainage that was the opposite direction of the truck at the "exit" trail head. And we walked and walked. And walked some more until about 2 AM. He estimated we covered about 30 miles. Maybe that's a bit high, but I have no qualms in asserting we walked at least 26.2 miles. I remember pulling two apples out of my Kelty pack about 1 AM, which he ate in the dark before switch-

backing up a slope to return to the highway. We also saw a magnificent shooting star about the same time. He probably saw that as a shake-down hike, to see what I was made of. I think I passed the test.

Ron's career was remarkable. Not many people publish numerous and substantive papers in revisionary/descriptive taxonomy covering three families. Ron did so in Asteraceae, Caryophyllaceae, and Apiaceae. What a career! And what a legacy of students he trained over those many years.

...I'll miss you, botanical friend and mentor.  
Thanks for the many great times.

Ron Hartman: Friend

Bill Gribb

University of Wyoming, Laramie, WY

I met Ron back in 1989 while working on a project to initiate GIS into four departments; Botany, Geology, Zoology and Geography. Ron saw the utility and analytical potential of GIS back when people were just learning how to spell it. This eventually led to the two of us receiving an NSF grant to start a program called the Digital Earth Science Laboratory, the integration of field collected artifacts and data into the geo-technological realm of GIS/Remote Sensing/GPS. Since that time we met almost once a week for the next 29 years to discuss the project, new research questions and life in general.

I have many stories to tell about my experiences with Ron, but I could be here all evening. After receiving the NSF grant we purchased a GPS unit and a bar coding device so that we could accurately locate and label field samples and have them automatically entered into a spatially-oriented database. To test the process we went out into the field and Ron followed his normal process of collecting botanical specimens along with the added procedure of using the GPS and putting bar code on each sample bag. After a 10 hour field day, Ron was frustrated with the results. We had collected samples from 40 different sites, had accurate latitude and longitude locations and bar coded and entered data about the plants, soils and geology. Everything that the grant intended to accomplish. Ron's frustration was that this process was too slow, and resulted in collecting at one-fourth to one-fifth of his normal speed and to collect at that speed he would have to either bring a second or third person into the field or figure out a different collection process. Both of these solutions were not immediately doable for Ron. Eventually, a new procedure was worked out so that he could maintain his rapid collection speed. You have to remember,

Ron, Ernie, their colleagues, students and volunteers increased the Rocky Mountain Herbarium's collections from 75,000 to over 1 million while Ron was the director and moved into computerizing, mapping and digitally imaging the collection.

While working on a project with me in Grand Teton National Park, Ron was identifying the different types of plants found in beaver habitats. To accomplish this one of our methods was to float, kayak or canoe down the river system in the park and once we found beaver activity catalog the area's plants, soils and physical characteristics. One day we were to canoe down the Snake River from Flagg Ranch to Lizard Creek, an area at the north end of Jackson Lake. Knowing Ron was an Eagle Scout with multiple outdoor merit badges, I thought this would be an easy task for him and put him in as the stern paddler or pilot of one of the canoes. Off we went down the Snake River with Ron and one of my research assistants in the second canoe. We came upon a series of rapids with the river taking a sharp turn to the left after the rapids. My canoe went down the rapids with no problems and negotiated the turn. When I looked back, the second canoe was negotiating its way through the rapids, but backwards and barely made the sharp left turn. Needless to say they crashed into the bank and stopped. I went back to find out what had happened and talked to Ron. I found out he did not have any experience in canoeing, but he thought he would give it a try. I guess I should have asked him if he had that merit badge...we switched pilots.

The one merit badge that I am sure he had was that of friendship.

Ron Hartman: Changing Lives

Brian Elliott

Elliott Environmental Consulting, Laramie, WY

I first met Ron in 1998 when I joined his floristics program as a graduate student. I quickly learned that working with Ron in the field was a challenge. Ron had a very rapid pace and should you stop to collect a plant he would nearly be out of site before you could get the plant out of the ground. I quickly learned to collect plants on the run virtually without breaking stride and to forego collecting anything with a bulb or deep-seated root until I was working alone. It was easy to become lost when working with Ron. You had to keep an eye on him, an eye on the car, and to remember where you were.

A few years ago Ron was honored with a lifetime achievement award from the Colorado Native Plant Society. I was asked to introduce Ron and quickly thought over what I believed were Ron's achievements. The first thing that comes to mind is his lifetime of contributions to Botany and the Rocky Mountain Herbarium. He contributed to floras, described new species, and made many other taxonomic contributions. His leadership of the Rocky Mountain Herbarium has left us with a tangible reminder of his work and passion for the Rocky Mountain flora.

Ron has another legacy that is perhaps less well known. He trained 52 graduate students in his floristics program and most of those students went on to make their own contributions to Botany. On the day he received the lifetime achievement award there were nine of his current or former students were in the audience, and incredible presence at one meeting.

I think of how fortunate I was to be accepted into his graduate program and how fortunate I was to gain a skill set that has enabled me to love my work and to do something I passionately believe in. Working with Ron changed my life and I will always be proud to say I am a Ron Hartman student!

The Family of Ron Hartman together with the Department of Botany, University of Wyoming, thank all who called, corresponded and came to the Celebration of Life on 8 February.

THANK YOU



### Pollination Primer (continued from p. 1)

Pollination by animals benefits the plants involved because their pollen grains, and thus their sperm, is moved from flower to flower. It benefits pollinators because they obtain substances, most commonly food in the form of nectar and pollen, in flowers. The interaction also benefits humanity. It is critical for the healthy functioning of natural and many agricultural ecosystems.

Figure 2 shows how it contributes to our diet. The top image is a market with, literally, the fruits of pollination. In the bottom image we see what we would have to eat if the interaction disappeared. Plants that are pollinated by wind would persist, so we would have cereal grains and some other things, but we'd lose much of what makes our meals so tasty, and many of our calories. Alas, the mutually-beneficial interaction between plants and pollinators is threatened by human activities—climate change, land use change, invasive species—and again alas, we will need to end this talk by mentioning another threat that is now emerging. There is no more important time than now for scientists to study pollination and for citizens to become informed.



Figure 3. Subalpine meadow near Gothic

### *Some History*

The scientific study of pollination actually dates to the 1760s—about 250 years ago. From even a much earlier time, surely, humans have been delighted and intrigued by the tremendous diversity of flowers, in their color, shape, scent, and presentation on the plant. Figure 3 shows one example from a subalpine meadow near the Rocky Mountain Biological Laboratory (RMBL) in western Colorado.

Scientists studying this interaction began early on to look for ways to classify this remarkable diversity, so

that they would not need to consider over 200,000 animal-pollinated species one-by-one!

The proposal that eventually gained wide acceptance is that many flowers can be grouped according to presumed reciprocal specialization with a particular type of pollinator. This idea was first fully presented by the Italian botanist Federico Delpino in a monograph in the 1870s (Figure 4).

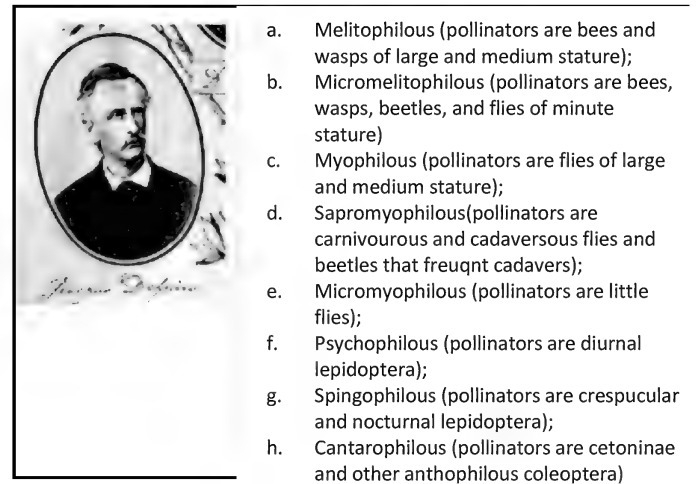


Figure 4. Delpino and flower-pollinator types

The modern versions of such schemes are referred to as pollination syndromes and the idea is that distantly-related plant species have converged through evolution in the characteristics of their flowers so as to attract and use one specific pollinator or another, and that the pollinators have reciprocated.

The question is: do the pollination syndromes correctly capture Nature's complexity, or do they miss some important aspects, perhaps even some central aspects, of how pollination interactions are organized?

### *The Longer You Look the More You See*

Let us begin to explore this question by recounting our own early history of work at the RMBL. Figure 4 shows a classic "hummingbird flower", scarlet gilia, *Ipomopsis aggregata*, which Nick began to study in 1972. Indeed, what was immediately apparent was visitation by hummingbirds, and our later experiments and those of others at the RMBL confirmed that most of the pollination comes from Broad-tailed Hummingbirds (a male is shown in Figure 4) and Rufous Hummingbirds. But the longer one sits in the meadows, the more years and valleys



one studies, the more one sees. We began to realize that many insects also visit scarlet gilia!

carry scarlet gilia pollen on their bodies, so probably do some pollinating too.

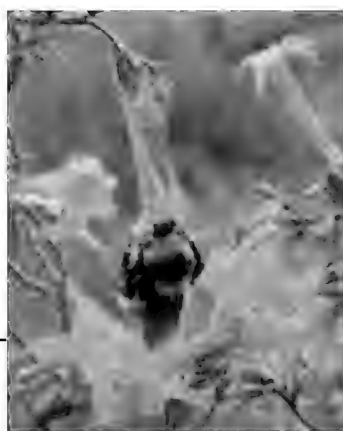
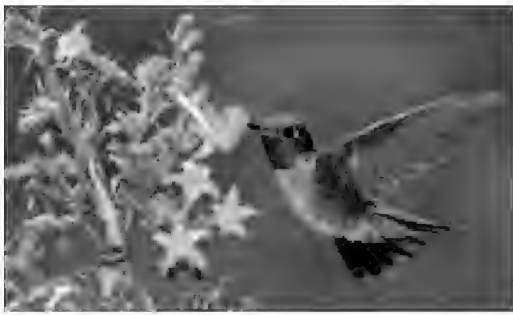


Figure 5 (above): Hummingbird and scarlet gilia, Photo by David Inouye; Figure 6 (right) Bumblebee and scarlet gilia.

Indeed, what was immediately apparent was visitation by hummingbirds, and our later experiments and those of others at the RMBL confirmed that most of the pollination comes from Broad-tailed Hummingbirds (a male is shown in Figure 4) and Rufous Hummingbirds. But the longer one sits in the meadows, the more years and valleys one studies, the more one sees. We began to realize that many insects also visit scarlet gilia!

We won't show you images of all the insects, but they include sphinx moths, butterflies, solitary bees, and hover flies and, as shown in Figure 5, also bumble bees. This is a queen of the bumble bee species *Bombus appositus*, which has a relatively long tongue with which she licks nectar. In some years and valleys these bees are systematic in their foraging at scarlet gilia flowers. It is possible to measure foraging speed and estimate what the bees are gaining from the flowers in terms of energy from nectar, and it turns out that they are realizing a very good caloric reward. They appear to be careful shoppers in the "floral supermarket", not deterred by red color, and visiting scarlet gilia when the profit is good.

You might well wonder, however, if this is pollination. The bees and other insects might visit but not pollinate—in effect stealing nectar. However, Margie Mayfield, who is now a Professor at the University of Queensland, Australia, showed 20 years ago as our undergraduate research intern that each bumble bee visit on average deposits three times as much pollen on a virgin scarlet gilia flower as does each hummingbird visit, and leads to four times as many seeds produced! These are not only pollinators, but good ones. The other insects we mentioned also

### *An Unbiased Look at Entire Communities*

Although we could try to argue otherwise, it's possible that scarlet gilia is a quirk of Nature, not representative. One way to see whether or not this is so is to look at an entire plant and pollinator community without any a priori filtering of which species to focus on. Ruben Alarcón, who is now a Professor at California State University, did just that in the 1990s at the RMBL, working in Virginia Basin, about 500 meters higher than the 2900 meter elevation of the RMBL.

What Ruben did was to walk transects through meadows every few days, counting all the flowers to get information on relative abundances of flowers of different species. He also recorded and identified visitors that touched the sex organs of flowers and thus were taken to be pollinators. The result is a striking realization that flowers and pollinators are connected in an intricate web or network of interactions, a pollination network or pollination web. Figure 7 (on the following page) shows one example from Virginia Basin.

The connections in the web are rich and many species are generalized, attracting diverse pollinators if they are plants or visiting diverse flowers if they are pollinators. There are certainly some specialists in these webs – but they tend to associate with generalists, not with other specialists as we had assumed! For example, then, a flower that attracts only a single pollinator is likely to attract one that itself visits lots of other flower species. This is very different from the co-specialization hypothesized by Delpino and subsequent generations of workers. And Ruben's webs are not unique; they resemble pollination webs that have now been characterized around the world.

We can now ask how stable the interactions in such a web are through time and space. The recent work of Paul CaraDonna at the RMBL sheds light on the first part of this question (and other scientists are beginning to explore variation through space). What Paul did was to walk transects near the RMBL just as Ruben had at higher elevation, but he analyzed the webs on a week-by-week basis through the short summer growing season.

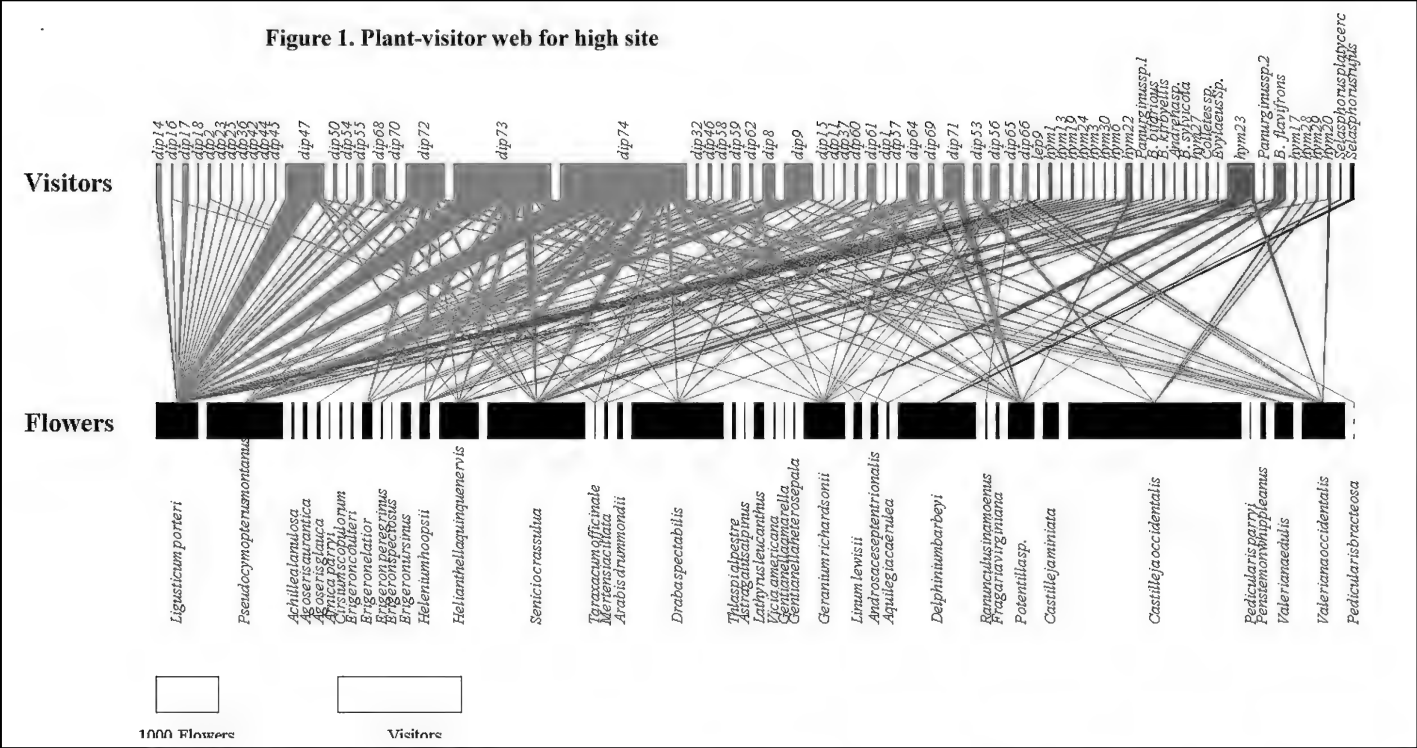


Figure 7. Plant-Visitor Web for High Site

Figure 8 shows the results for the summer of 2014. You can see that these webs resemble the Virginia Basin web we showed in Figure 7, but you notice immediately that they change week-to-week. In part this is no surprise – there must be change because of species turnover through the season. As the season progresses from spring snowmelt through to first frost of autumn, different plants are coming into flower and ceasing to flower, different insects are emerging and flying and ceasing to fly.

But what is exciting and intriguing is that species turnover is not responsible for all of the turnover of interactions from week to week in Paul’s meadows – in fact, it is not even the major cause. On average about two-thirds of interaction turnover can be attributed to rewiring (Figure 9), that is, species that remain in the community across several weeks begin to interact or cease to interact from time to time not because they have appeared or disappeared but because they abandon one another or take up with one another for reasons we must now begin to investigate. Is it all “careful shopping” as with bumble bees and scarlet gilia? Do pollinators “divorce” some flowers if more attractive options appear or become more common? These are new questions to pursue.

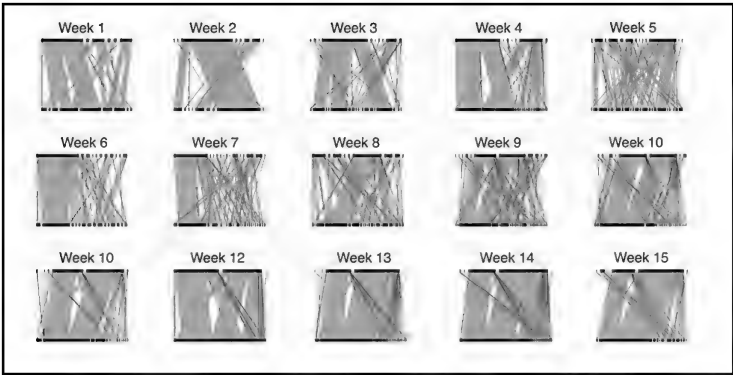


Figure 8. CaraDonna’s 2014 weekly research results.

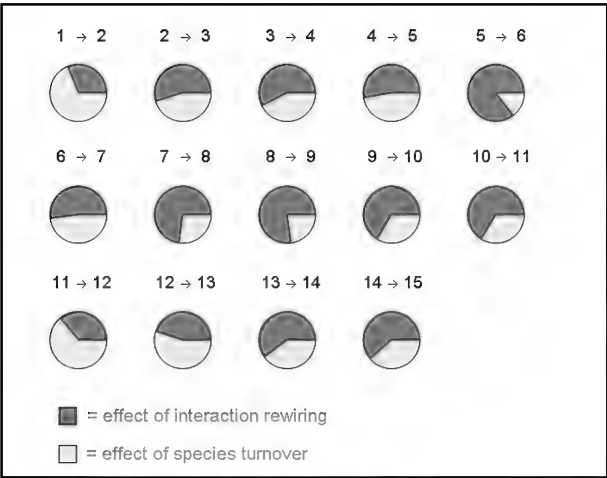


Figure 9. Weekly effect of rewiring vs. species turnover (relationship changes in Figure 8)

### Lessons for Citizens

We draw several conclusions from this sketch of 40 years of research.

First, let us recognize pollination by animals as a critical ecological interaction involving most species of flowering plants and many insects and other animals. In other words, not every pollinator is a bee and not every bee is a honey bee (we stress this because the public perception often seems to be that honey bees are “it”).

In fact, as Figure 7 hints, the very diversity of types of pollinators visiting a flower seems to confer superior pollination to the plant. More studies of this sort of effect are ongoing. But for now, as lovers of native plants and gardens we say: plant your gardens for diversity and advocate for wildland diversity and for pockets of semi-natural habitat within urban and agricultural landscapes—all of which fosters pollinator diversity and ecosystem health.

Second, we’ve seen that plants and pollinators are connected in a web of interactions, and that some degree of generalization and flexibility are common. In other words, don’t think of each plant as having “its pollinator”. To be sure, some plants are specialists, but this is not the most common condition.

Finally, remember that schemes for determining pollinators based on how flowers look are only a rough guide. In general, don’t take human-constructed hypotheses too seriously or let them come between you and Nature—keep your eyes open and trust what you see! Welcome surprise!

...Alas, there is a further lesson to bring up, and here we return to the human-caused threats to the plant-pollinator interaction. Honey bees (*Apis mellifera*) are one of the few human domestications of an insect, and the domestication has been extremely successful and important to humanity. But some of us are not treating honey bees all that well. For pollination of some crops, honey bee colonies are transported around North America and even from other countries. This, and the stressful conditions the colonies are sometimes subjected to, has led quite recently to spread of diseases among honey bees worldwide.

Figure 10 shows an image of a parasitic mite, *Varroa destructor*, attached to the thorax of a honey bee worker. These mites are a drain on the health of the

bee, and also are one of several vectors for transmission of a host of viral and other diseases.

To make things worse, these diseases are now spilling over from honey bees into native bees such as solitary bees and bumble bees.



Figure 10. Mite on bee (Wikipedia commons)

Studies are now beginning to appear that document the spill-over—something that you may think about as a kind of “Ebola virus” situation with insects. Recall that Ebola and other emerging diseases that threaten human pandemics have arisen recently through lateral transfer from other animals (African fruit bats in the case of Ebola.)

Let us then finish with some final thoughts for you to take home as citizen advocates. Native bees (and other native pollinators) are excellent pollinators of our native plants, which benefit from their diversity. Due to no fault of their own, honey bees are now infected worldwide with a host of diseases. These are threatening native bees. Therefore: it is not necessary to advocate for honey bees as pollinators in wildlands, and in fact best to work for the opposite—for keeping them as much as possible away from contact with native systems, which are functioning just fine without them!

Original Acknowledgements. We thank Irene Shonle for inviting us to participate in the 2016 CoNPS Meeting, Jan and Charlie Turner for hosting us and encouraging us to prepare this article, and the Rocky Mountain Biological Laboratory for logistical support over our many summers of research there.

*Recommended Reading (Continued p. 20)*

## Growing Native Plants

### **Part 31. More Forbs for Dryer Sites**

By Robert Dorn

*Argemone polyanthemos*, Annual Pricklypoppy, is an annual or more commonly a short-lived perennial to 2.5 feet tall. The leaves are thistle-like and prickly, to 8 inches long, and blue-green with often white veins. The stems are also prickly. The flowers are quite large, to 4 inches across, with white petals, yellow stamens, and purple stigmas. They are solitary in the upper leaf axils and appear from May to September, a long flowering period. The plants occur naturally in sandy or gravelly areas on the eastern plains of the state. They prefer full sun and dry, sandy, well drained soils and are drought tolerant. The plants are poisonous to livestock but usually not consumed. They can be grown from seed sown outdoors in the fall. Seed is commercially available. It readily reseeds.



*Argemone polyanthemos*, Goshen County

*Dalea purpurea*, Purple Prairieclover, is a perennial to 2 feet tall usually with several stems. The leaves are compound with 3 to 7 narrow leaflets each to 1.75 inches long. The flowers are purple or pink-purple, each about .25 inch long, and arranged in a dense spike about 3 inches long at the tip of the stem. They appear in July and August. The plants occur naturally on dry, often rocky sites in the plains and basins mostly in the eastern half of the state. They prefer full sun and well drained soils but will tolerate some clay and they are drought tolerant. They can be grown from seed which

has been cold stratified for at least 10 days for spring planting. The seed should also be scarified before planting. Dividing and/or transplanting are difficult. It is also in the nursery trade.



*Dalea purpurea*, Albany County

*Hymenoxys richardsonii*, Colorado Rubberplant, is a perennial to 14 inches tall and nearly as wide with few to many stems. The leaves are to 5 inches long and deeply divided into narrow segments. The flower heads are at the stem tips, yellow, with ray flowers 3 toothed at the tip. The heads are to 1 inch across with up to 30 heads per plant. They appear from May to July. The plants occur naturally in dry, rocky places of the plains, basins, valleys, and mountains mostly in the western 2/3 of the state. They prefer full sun and well drained soils. They are poisonous to livestock but seldom eaten if better forage is available. They can be grown from seed without any special treatment. It is also in the nursery trade.



*Hymenoxys richardsonii*, Daggett County, UT

*Lygodesmia grandiflora*, Largeflower Skeletonweed, is a perennial to 2 feet tall and 8 inches wide. The leaves are very narrow and grass-like and to 6 inches long. The flower heads are usually solitary at the tip of each stem, to 1.5 inches across, and the flowers pink to pale lavender. They appear in May and June. The plants occur naturally in dry, often sandy, open areas of the plains and basins mostly in the southern middle third of the state. They prefer full sun and dry, well drained, sandy soils. They will tolerate some alkalinity. They are easily grown from seed.



*Lygodesmia grandiflora*, Sweetwater County

*Solidago mollis*, Soft Goldenrod, is a perennial to 1.5 feet tall with one to several stems from a creeping rhizome. The leaves are to 3 inches long and to 1 inch wide. The flower heads are small, less than 0.5 inch tall and wide but are densely clustered in an elongate inflorescence. The flowers are yellow and appear from July to October. The plants occur naturally on dry sites in the plains and basins over much of the state except for the southwest. They prefer full sun and dry, well drained soils. They can be grown from seed surface sown outdoors in the fall. Don't expect high germination. It can also be grown from rhizome cuttings.



*Solidago mollis*, Sioux County, NE

To see the above plants in color, go to the newsletter on the Society website.

## Announcing: Wyoming's Guide to Native Bees

By Lusha Tronstad and Michael Dillon



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Pollination Primer, continued from p. 17

### Recommended Reading

- Alarcón, R., N. M. Waser and J. Ollerton. 2008. Year-to-year variation in the topology of a plant-pollinator interaction network. *Oikos* 117:1796-1807.
- CaraDonna, P. J., W. K. Petry, R. M. Brennan, J. L. Cunningham, J. L. Bronstein, N. M. Waser, and N. J. Sanders. 2017. Interaction rewiring and the rapid turnover of plant-pollinator networks. *Ecology Letters* 20:385-394
- Fontaine, C., I. Dajoz, J. Meriguet and M. Loreau. 2006. Functional diversity of plant-pollinator interaction webs enhances the persistence of plant communities. *PLoS Biology* 4(1)0129-0135.
- Mayfield, M.M., N.M. Waser and M.V. Price. 2001. Exploring the 'Most Effective Pollinator Principle' with complex flowers: bumblebees and *Ipomopsis aggregata*. *Annals of Botany* 88: 591-596.
- Ravoet, J., L. De Smet, I. Meeus, G. Smagghe, T. Wenseleers, D. C. de Graaf. 2014. Widespread occurrence of honey bee pathogens in solitary bees. *Journal of Invertebrate Pathology* 122:55-58.
- Waser, N.M., J. Ollerton and A. Erhardt. 2011. Typology in pollination biology: Lessons from an historical critique. *Journal of Pollination Ecology* 3(1): 1-7.

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